

Engineering Science Series

**ROUTE SURVEYS
AND CONSTRUCTION**

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ROUTE SURVEYS AND CONSTRUCTION

A Pocket and Reference Book with Tables
for the Survey, Design, and Construction
of Highways, Railways, Airways, Tramways,
Beltways, Canals, Flumes, Levees, Pipe Lines,
Transmission Lines, and Other Route
Constructions
for

Students, Professional Engineers,
Construction Engineers, and Contractors

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THIRD EDITION OF ROUTE S.

THE MACMILLAN COMPANY, NEW YORK

PREFACE

This third edition is based on 50 years of the practice and teaching of routes. It has been revised through three editions and numerous printings to serve as a text and permanent reference book emphasizing professional civil engineering and its trend towards the profitable fields of engineered construction, contracting, professional management, and the expanding practical uses of photogrammetry. Fundamentals and disciplines are retained but the traditional field surveying flavor is diminished.

It has been kept in mind that the course in route surveys must provide the engineering approach and the broad basic treatment underlying highways, railways, airways, canals, pipe lines, transmission lines, cableways, beltways and all transportation and communication constructions. Obviously it cannot provide complete coverage of such a wide variety of fields in any of which the graduate may practice. Furthermore, corporations or governmental branches engaged in these fields have varying standards of practice, accompanied by pride of opinion. Since the work of the graduate varies so widely, it would be misleading and narrowing to concentrate on any one field or any single standard practice, as was once done for railways and as is now being done for highways. While highway, railway, and hydraulic constructions are emphasized in this text, other applications are indicated. It is the author's conviction that the engineer should be educated broadly and professionally, not trained narrowly in the techniques of a special field.

Few engineering curricula allow adequate courses and time for engineered construction with its relation to professional management and for modern photogrammetric applications; hence their inclusion in this edition. It is suggested that the economic studies, estimates, and bids of chapters XV and XVII may be made as part of a project investigation in the routes.

construction, or professional management courses. Perhaps in this indirect manner a little additional time may become available for consideration of routes.

Regardless of whether the study of routes be limited to an unduly brief geometric treatment in the sophomore year, a more elaborate study in the junior year, or preferably a professional design and economic project study in the senior year; all civil engineering students, constructors, practitioners, and managers need complete reference material and tables for routes close at hand throughout their careers. The book has been prepared for this overall permanent use as well as for class use in all types of routes courses. Selected chapters may be assigned and covered to any extent desired but the treatment is comprehensive. Any shorter text or any specialized treatment such as is given in railway, highway, and similar manuals necessarily must be on a sub-professional or technician basis unsuited to professional collegiate curricula or for broad professional reference.

Better, broader, and more comprehensive coverage is provided in this book than in other texts for such matters as:

1. More tables, with latest revisions and corrections.
2. Tables and text suitable for arc, chord, and other definitions of degree of curve, including latest methods and tables for staking curves with a tape on secondary roads, logging roads, canals, and the like.
3. Tables and text suitable for the American Railway Engineering Association (railway), the Barnett (highway), and other spirals, treated fundamentally.
4. The latest developments for both string lining (from A.R.E.A. Manual and newest mechanical equipment) and transit lining, on existing railway curves.
5. Several methods of staking railway turnouts.
6. Highway and photogrammetric applications.
7. New chapters and emphasis on the growing and remunerative fields of engineered construction, professional management, and contracting, including estimating and bidding
8. The long-established Macmillan five-place natural trigonometric and log tables that are most efficient for general use. For

rare usage, eight-place natural sines and cosines have been added. No such precise tables are available to most engineers.

9. Facilitating reference by continuing to number all figures, tables, and formulas to correspond to the section in which they occur and giving the chapter and section numbers at the top of each page.

10. Perfecting and expanding the index to increase the reference value of the book and tables.

11. Including extensive problems with answers to the (a) problem in each case so that the student can check them while studying. Similar (b), (c), and (d) problems with varying numerical data are added for examining or quizzing the student.

12. Retaining the type which is more easily read than is that of most pocket books.

13. Avoiding verbose description or formulation which makes a text difficult to follow and removes the student's incentive to reason from a figure and to exercise his own initiative and judgment. On the contrary, figures are ample but simple and the student must give his own thoughtful study to the figures, formulas, and text. Reasoning on the part of the student thus becomes necessary in solving the problems, in explaining simple missing steps in the development of formulas, and in his economic design of location on maps and profiles or on the ground. Open or closed book examinations may then use both problems and objective questions.

14. Perfecting the text and tables through a score of printings and editions.

15. Outlining a project method for teaching a route survey course, as given in Section 12a.

16. Furnishing teaching aids, on request from teachers, especially designed for this book and for the larger classes.

17. Encouraging a professional, rather than a sub-professional, approach.

The more notable changes in this edition place emphasis on professional engineering, engineered-construction, professional management, contracting, and practical photogrammetry; these being the more promising and profitable outlets for the majority

of civil engineers. Here their future is unlimited, whichever way their interests and opportunities develop.

The cooperation of associates in teaching and practice, of students, of manufacturers, of transportation agencies, and of governmental agencies is gratefully acknowledged. The author will be most appreciative of further suggestions for improvement that may be brought to his attention.

HARRY RUBLY

Columbia, Mo.

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ROUTE SURVEYS AND CONSTRUCTION

CHAPTER I

INTRODUCTION

1. Importance of Route Surveys and Construction. Construction, with its accompanying replacement and maintenance, has become our largest industry, accounting for one seventh of our expenditures. It is a most profitable field for civil engineers and offers preferred entree into management. Much of this rapidly growing activity is based on the fundamental data contained herein.

This book presents the principles underlying the design of location, survey, and construction of highways; railways; airways; gas, oil, and water pipeline lines; canals and water conveying conduits and flumes; electrical transmission lines; telephone and telegraph lines; tunnels and underground conduits; cableways; beltways; and other means of conveying or transmitting goods, materials, power, or power impulses over long distances on the surface of the earth.

The foregoing routes comprise America's multimillion-mile system of transportation and communication where perhaps one-fifth of our national wealth is invested. The cost per mile for constructing routes varies from a few thousands to many millions of dollars, and operating equipment is equally costly.

Present civilization, its future development, and the high standard of living of this country are dependent to a considerable extent upon its elaborate transportation and communication system. Kipling has said "Transportation is civilization."

In the past, most route construction projects were designed to meet only existing needs, with the result that a large part of this construction is now obsolete. Railways